Risks of Lithium Batteries

Events & Consequences: Part 1

Presented to: 62nd Annual Business Aviation Safety Summit (BASS)

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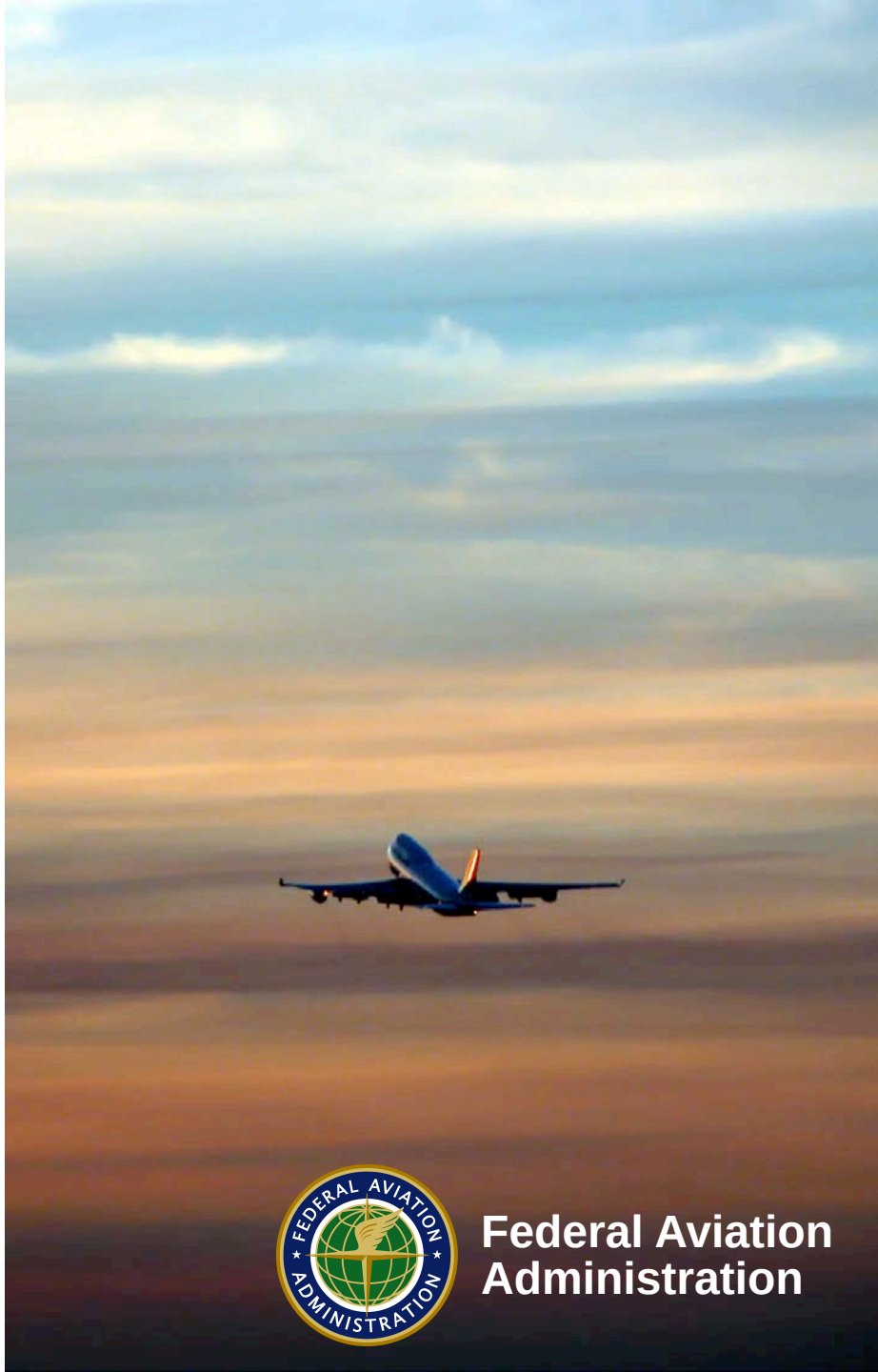
Date: May 5, 2017



Introduction

- **Lithium Battery Incident Data**
- **Examples of Recent Incidents**
- **Lithium Battery Safety Concerns during an Incident In-Flight**
- **ICAO Emergency Response Guide (ERG/Redbook)**
- **Safety Risk Assessments**
- **References**

FAA List of Lithium Battery Incidents

- **Current total is around 150+ incidents**
- **From 1994 to the present**
- **Indications would indicate this is just a fraction of the worldwide events involving lithium batteries in aviation**

- https://www.faa.gov/about/office_org/headquarters_offices/ash/ash_programs/hazmat/aircarrier_info/media/battery_incident_chart.pdf

LITHIUM BATTERIES & LITHIUM BATTERY-POWERED DEVICES

Aviation Cargo and Passenger Baggage Events Involving Smoke, Fire, Extreme Heat or Explosion Involving Lithium Batteries or Unknown Battery Types

In an effort to more closely focus on lithium battery events, this list has been revised to include events involving lithium or unknown battery types.

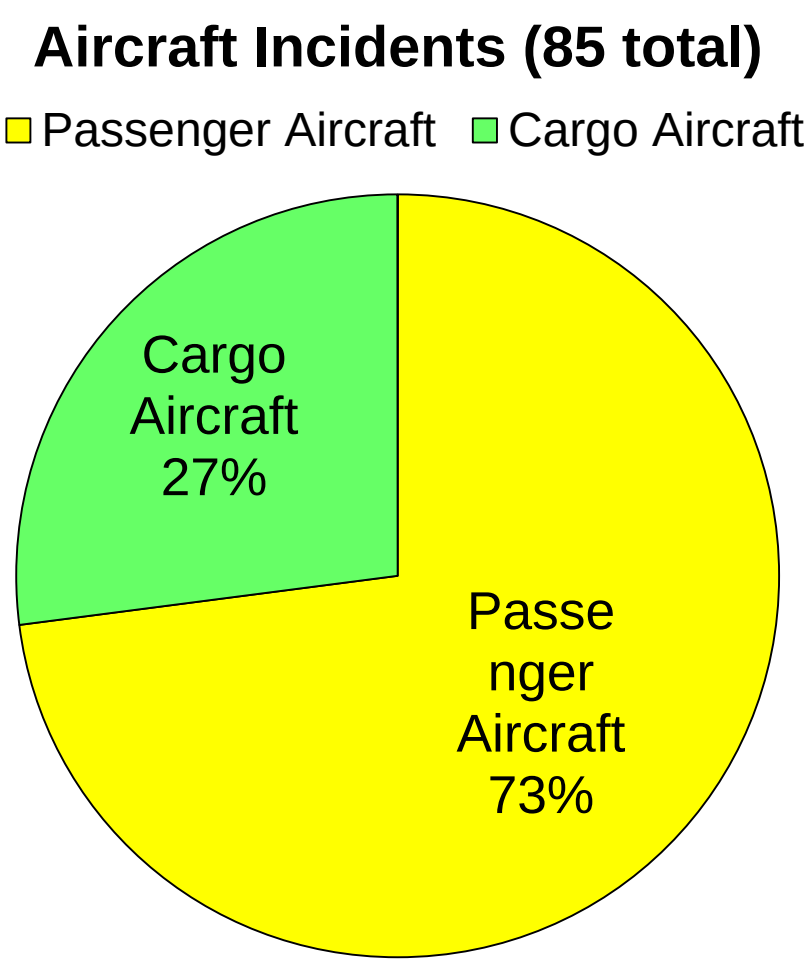
As of March 27, 2017, 152 air/airport incidents involving lithium batteries carried as cargo or baggage that have been recorded since March 20, 1991

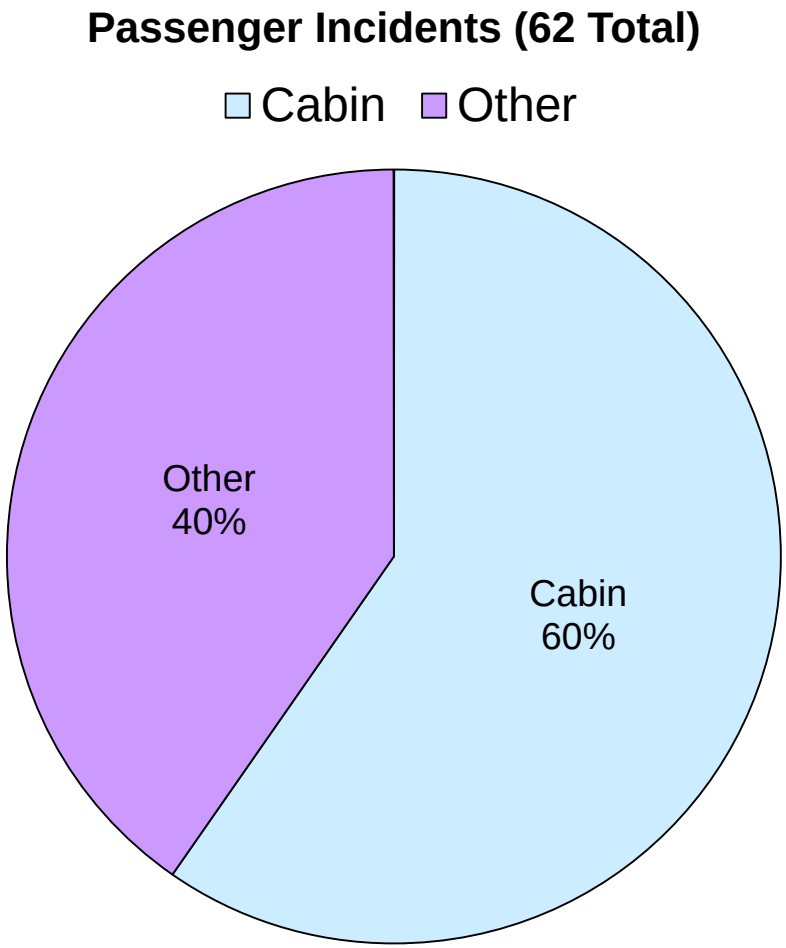
Note: These are recent cargo and baggage incidents that the FAA is aware of. This should not be considered as a complete listing of all such incidents. The incident summaries included here are intended to be brief and objective. They do not represent all information the FAA has collected, nor do they include all investigative or enforcement actions taken. This list does not include three major aircraft accidents where lithium battery cargo shipments were implicated but not proven to be the source of the fire: An Asiana Airlines 747 near South Korea on July 28, 2011, a UPS 747 in Dubai, UAE on September 3, 2010 and a UPS DC-8 in Philadelphia, PA on February 7, 2006

Date	Source	Type of Battery	Device (if applicable)	Carrier	Aircraft Type (Passenger or Cargo)	Incident Summary
2/27/2017	Carrier	Li-ion	iPhone	American Airlines	Passenger	On AA Flight 133 from JFK to LAX a passenger seated in the first class cabin was charging an iPhone and the battery overheated. The flight attendant placed the device in a coffee pot. No diversion required, no aircraft damage and the only injury was to the passengers hand.

As of 3/27/2017
FAA Office of Security and Hazardous Materials Safety

Lithium Battery Incidents – Last 5 Years





What Does That all Mean?

- **Of the lithium battery incidents reported, more are occurring on passenger aircraft (75%)**
- **Of those, 60% occurred in the cabin**
- **So the highest lithium battery incidence occurrence area in the last 5 years,**

is the cabin of the aircraft.

Breakdown of the 37 Cabin Incidents

Lithium Battery Cabin Incidents (last 5 years)	%	# of Incidents
Battery/Device (not during charging)	38%	14
Battery/Device (while charging)	22%	8
E-Cigarettes	19%	7
Battery short circuit	13%	5
Seat crushed/damaged battery/device	8%	3

E-Cigarette at Las Vegas Airport

- **April 11, 2017**
- **Mans hand and leg receives third degree burns and is hospitalized**

- "To say that this is terrifying is an understatement," said Scott Hildreth, the burn victim.

- **Sources:** http://www.ktnv.com/news/man-burned-inside-las-vegas-airport

  https://www.gofundme.com/prayer-support-for-scott-hildreth

Lithium Battery Incident Safety Concerns

- **Lithium ion batteries in thermal runaway**
  - A battery can catch on fire or create enough heat to cause severe burns
  - Smoke/gases emitted obscures vision
  - Gases contain highly flammable Hydrogen gas and hydrocarbons (can cause explosions in confined spaces)

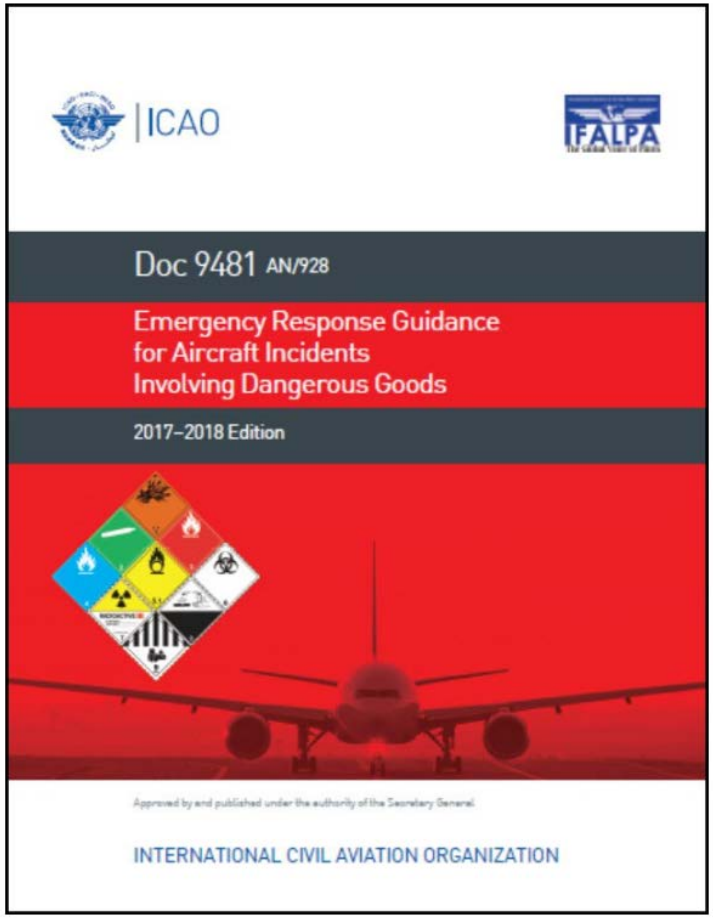
Video on Laptop Thermal Runaway in the Cockpit

- **The video can be downloaded from its original presentation at:**

https://www.fire.tc.faa.gov/2013Conference/files/Battery_Fires_I/SummerEFB/SummerEFBPres.pptx

12/3/2013	Boeing Battery Task Group: Mitigating the Risk of Carrying Lithium Batteries as Cargo	Darrin Noe,Boeing Battery Task Group Doug Ferguson,Boeing Commercial Airplanes Mike Madden,Boeing Battery Task Group Mary Xing,Boeing Battery Task Group Joe Yin,Boeing Battery Task Group
12/3/2013	Cockpit Visiability Impairment from an Electronic Flight Bag with Lithium Batteries in Thermal Runaway	Steve Summer,FAA Fire Safety Branch
12/3/2013	A Freighter Airplane Cargo Fire Risk, Benefit and Cost Model	Ray Cherry,RCW Cherry and Associates
12/3/2013	Test Method For Simulating Internal Short Circuits In Lithium Cells	Alvin Wu,UL Mahmood Tabaddor,UL Carl Wang,UL

ICAO Emergency Response Guidance for Aircraft Incidents Involving Dangerous Goods



ICAO Emergency Response Guidance (ERG) for Aircraft Incidents Involving Dangerous Goods

- **Battery/Portable Electronic Devices (PED) Fire/Smoke**
- **Overhead Bin Battery/Portable Electronic Device (PED) Fire/Smoke**
- **Overheated Battery/Electrical Smell Involving a Portable Electronic Device (PED)-No Visible Fire or Smoke**
- **PED Inadvertently Crushed or Damaged in Electrically Adjustable Seat**

ICAO Emergency Response Guidance (ERG) for Aircraft Incidents Involving Dangerous Goods

- **For each incident scenario, the ERG has both:**
  - A basic Checklist format; and
  - An amplified Checklist in more detailed paragraph form

3.3 CABIN CREW CHECKLIST FOR DANGEROUS GOODS INCIDENTS IN THE PASSENGER CABIN DURING FLIGHT

BATTERY / PORTABLE ELECTRONIC DEVICE (PED) FIRE / SMOKE	
Step	**Cabin Crew Action**
1.	Identify the item *Note. — It may not be possible to identify the item (source of fire) immediately. In this case, apply Step 2 first, and then attempt to identify it.* Caution: In order to avoid injury from a flash fire, it is not recommended to open the affected baggage when there is any indication of smoke or flames
2.	Apply fire-fighting procedure: i. Obtain and use the appropriate fire extinguisher ii. Retrieve and use protective equipment, as applicable to the situation iii. Move passengers away from the area, if possible iv. Notify pilot-in-command / other cabin crew members *Note. — Actions should occur simultaneously in a multi-crew operation*
3.	Remove power: i. Disconnect the device from the power supply, if safe to do so ii. Turn off in-seat power, if applicable iii. Verify that power to the remaining electrical outlets remains off, if applicable Caution: i. Do not attempt to remove the battery from the device
4.	Douse the device with water (or other non-flammable liquid) *Note.— Liquid may turn to steam when applied to the hot battery*
5.	Leave the device in its place and monitor for any re-ignition i. If smoke or flames re-appear, repeat Steps 2 then 4 Caution: i. Do not attempt to pick-up or move the device ii. Do not cover or enclose the device iii. Do not use ice or dry ice to cool the device

BATTERY / PORTABLE ELECTRONIC DEVICE (PED) FIRE / SMOKE	
Step	**Cabin Crew Action**
6.	When the device has cooled (e.g. approximately 10 to 15 minutes): i. Obtain a suitable empty container ii. Fill the container with enough water (or other non-flammable liquid) to submerge the device iii. Using protective equipment, place the device in the container and completely submerge in water (or other non-flammable liquid) iv. Stow and (if possible) secure the container to prevent spillage
7.	Monitor the device and the surrounding area for the remainder of the flight
8.	After landing at the next destination: i. Apply operator's post-incident procedures

3.4.1 BATTERY / PORTABLE ELECTRONIC DEVICE (PED) FIRE/SMOKE

1) IDENTIFY THE ITEM

It may not be possible to identify the item (source of fire) right away, especially if the fire has started in a seat pocket or the device is not readily accessible. In this case, fire-fighting procedures should be applied as a first step. Once it is possible to do so, identify the item after the fire is under control. If the item is contained in baggage, the crew's actions would be similar to the actions for a device that is visible or readily accessible.

Caution:
In order to avoid injury from a flash fire, it is not recommended to open the affected baggage when there is any indication of smoke or flames. However, in certain situations cabin crew members may assess and deem it necessary to slightly open baggage to allow entry of the extinguishing agent and non-flammable liquid. This should be done with extreme caution and only after donning appropriate protective equipment, available on the aircraft.

2) APPLY FIRE-FIGHTING PROCEDURE

Any occurrence concerning a fire in the cabin should be notified immediately to the pilot-in-command who should be kept informed of all actions taken and of the effect. It is essential that the cabin crew and the flight crew coordinate their actions and that each are kept fully informed of the other's actions and intentions.

Appropriate fire-fighting and emergency procedures must be used to deal with any fire. In a multi-cabin crew operation, the actions detailed in the fire-fighting procedure should be conducted simultaneously. On aircraft operated with only one cabin crew member, the aid of a passenger should be sought in dealing with the situation.

Halon, Halon replacement or water extinguisher should be used to extinguish the fire and prevent its spread to additional flammable materials. It is important to wear available protective equipment (e.g. protective breathing equipment, fire gloves) when fighting a fire.

If fire develops, cabin crew should take prompt action to move passengers away from the area involved and, if necessary, provide wet towels or cloths and give instructions for passengers to breathe through them. Minimizing the spreading of smoke and fumes into the flight deck is critical for the continued safe operation of the aircraft, therefore it is essential to keep the flight deck door closed at all times. Crew communication and coordination is of utmost importance. The use of the interphone is the primary means of communication unless the interphone system fails.

Safety Risk Assessment

- **Business Aircraft have very small passenger cabins (Learjet 45: 375 ft^3, Citation Jet: 186 ft^3)**
- **A 9 cell (80 Wh) laptop battery can generate a tremendous amount of smoke**
- **FAA Order 8040.4A: Safety Risk Management Policy**
- **Notice 8900.344** (Appendix C: Sample Risk Assessment)

Safety Risk Assessment

- **When a lithium battery thermal runaway event occurs on your aircraft, will you be ready?**
  - To contain the fire
  - To protect the aircraft, crew, and passengers
  - To stop the thermal runaway from spreading to other cells in the battery
- **Understanding the risks and having a mitigation strategy in place could make a big difference in the overall outcome**

Video on a Tablet Thermal Runaway in the Galley

- **The video can be downloaded from its original presentation at:**

https://www.fire.tc.faa.gov/ppt/systems/May15Meeting/Maloney-0515-E-tabletFireTests.pptx

5/12/2015	Fire Hazards of Lithium Ion Batteries	Richard Walters,FAA Fire Safety Branch James Quintiere,University of Maryland Sean Crowley,FAA Fire Safety Branch Richard Lyon,FAA Fire Safety Branch
5/12/2015	E-Tablet Fire Tests: Storage in the aircraft	Thomas Maloney,FAA Fire Safety Branch
5/12/2015	Lithium Battery Thermal Runaway Vent Gas Analysis: Composition and Effect of Combustion	Thomas Maloney,FAA Fire Safety Branch

References

- **Safety Alerts for Operators (SAFO) 16001:** Risks of Fire or Explosion when Transporting Lithium Ion or Lithium Metal Batteries as Cargo on Passenger and Cargo Aircraft
- **SAFO 15010:** Carriage of Spare Lithium Batteries in Carry-on and Checked Baggage
- **Notice 8900.344:** Transportation of Lithium Ion and Lithium Ion Polymer Batteries as Cargo (Appendix C: Sample Risk Assessment)

References

- **SAFO 09013:** Fighting Fires Caused By Lithium Type Batteries in Portable Electronic Devices
- **SAFO 09013 SUP:** Supplemental info to SAFO 09013. Link to SUP in SAFO 09013.
- **ICAO DGP/24 Working Paper 81**, Addendum1 to the Final Report: Proposed amendments to the Emergency Response Guidance for Aircraft Incidents relating to lithium batteries.

http://www.icao.int/safety/DangerousGoods/DGP%2024%20Working%20Papers/DGP.24.WP.081.AddCorr.en.pdf

References

- **Advisory Circular (AC) 20-42D:** Hand Fire Extinguishers for Use in Aircraft
- **AC 120-80A:** In-Flight Fires
- **SAFO 16011:** Air Transport Restrictions for Recalled Lithium Batteries and Lithium Battery Powered Devices
- **SAFO 15003:** Fire Risk of Electronic Cigarettes (e-cigarettes) in Checked Baggage

Summary

- **Lithium Battery Incidents in the Cabin of the Aircraft:**
  - **Occurring more frequently than ever**
  - **Understand the risks, think about the potential scenarios that can occur, and develop a mitigation plan**
  - **Utilize the various references and resources available**

Presenter

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May 4–5
PHOENIX, ARIZONA
62nd annual Business Aviation Safety Summit
BASS 2017

RISKS OF LITHIUM BATTERIES

Events & Consequences: Part 2

Captain John Cox
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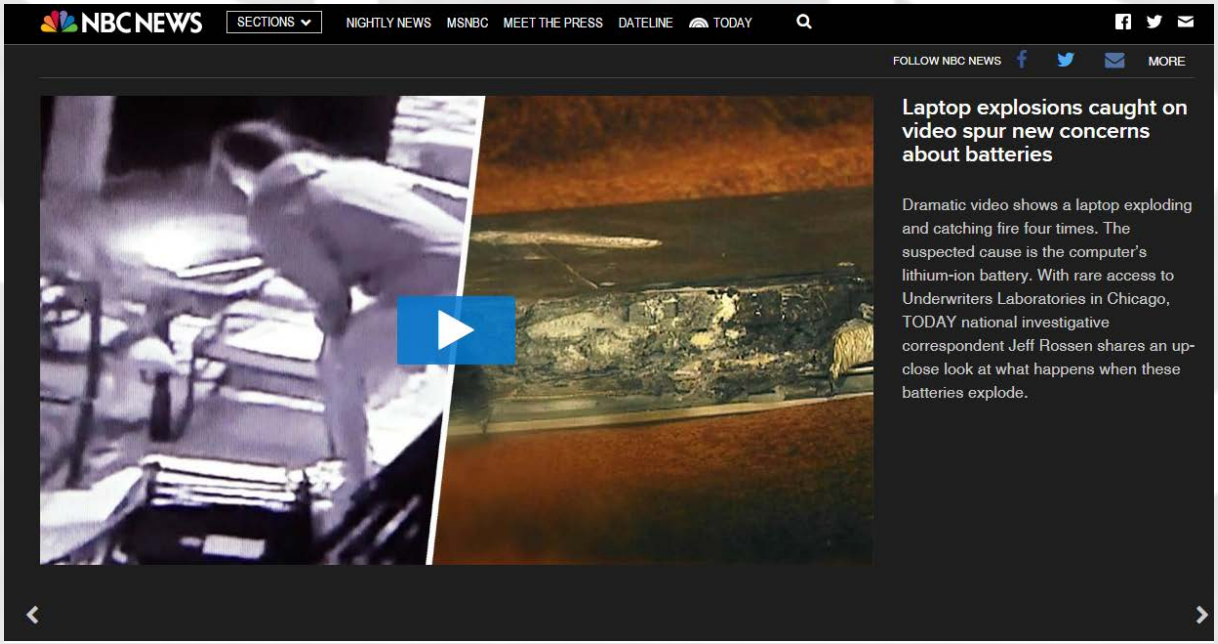
Safety Operating Systems

NBC Video Laptop Fire

- A similar video can be seen at the following location:

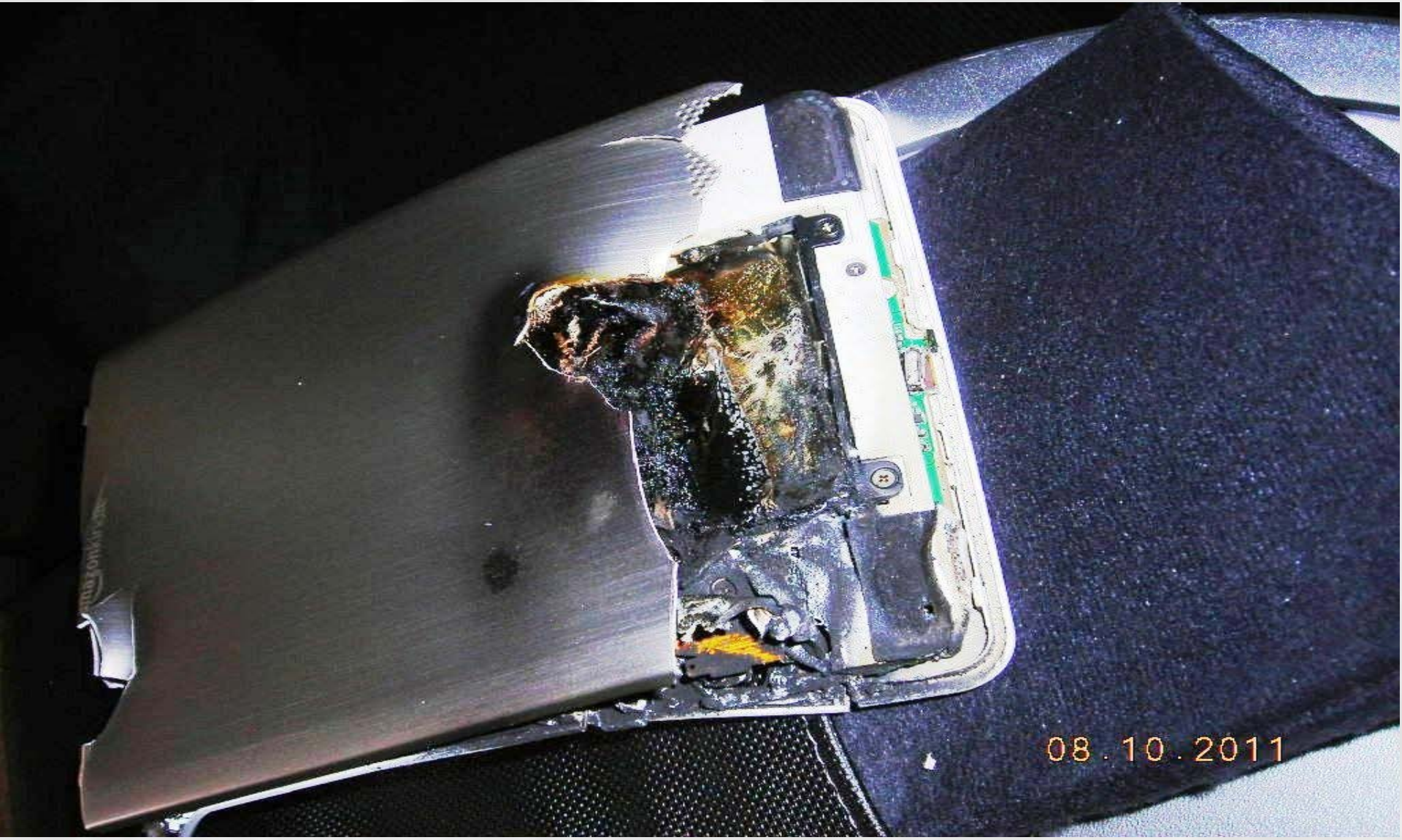
http://www.nbcnews.com/video/laptop-explosions-caught-on-video-spur-new-concerns-about-batteries-870874179709



Rising Risk

- Aviation is getting safer
- Lithium battery fires are increasing
- Trend is likely to continue

iPad vs. Seat



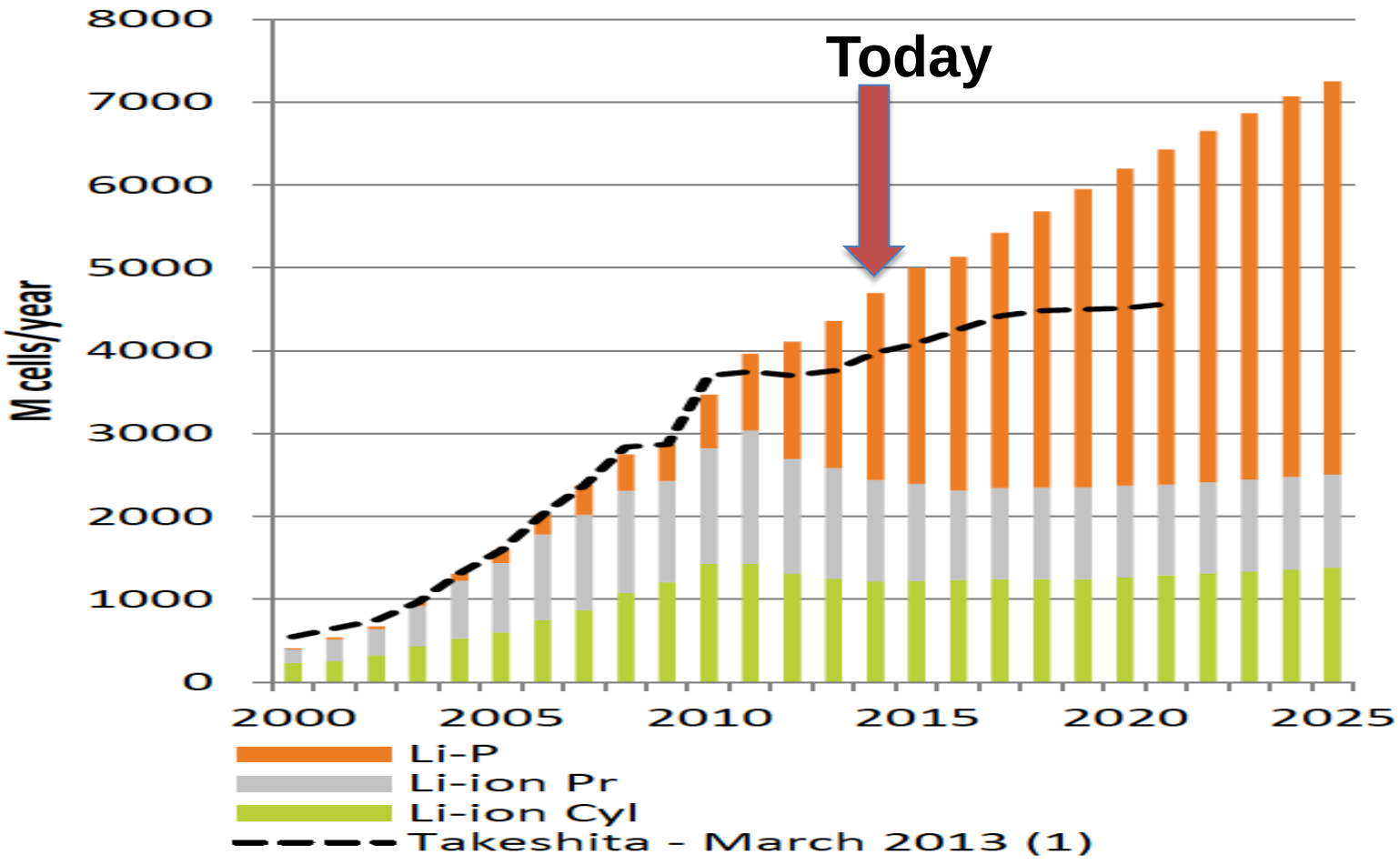
March 19, 2016

Thermal runaway on Alaska Airlines flight

September 7, 2016

Demand

2000-2025 LIB market, M cells, by form factor (3C)



(1) Source: Takeshita, Battery Japan 2013 BJ-3 conference – Slide p 4

Extra Consideration For Business Aviation

- Smaller cabin
  - Smoke will have a greater impact on occupants
- If there is no flight attendant then a pilot must be the fire fighter
  - Pilot incapacitation a risk
- Flight deck PED thermal runaway
  - Pilot(s) incapacitation

Smoke / Organic Vapor / Vent Gas

- Serious consideration
  - Mucus Membrane irritant
    - Eyes
    - Breathing
- Highly Flammable
  - Hydrogen
  - Ether
- High Quantity

Essentials

- Guidance
  - Improved Guidance from FAA
- Training
  - Improved and more standard training for flight crews
- Maintain aircraft control
  - Smoke and flight deck procedures
- Capture/Containment
  - Safe capture
  - Total containment

Presenter

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